Peer Review
Visualization and Controls

October 17, 2006

OE Mission

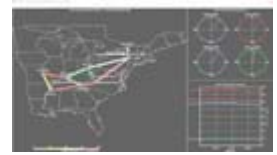
- Lead National efforts to modernize the electric grid, enhance security, and reliability of the energy infrastructure and facilitate recovery from disruptions to the energy supply.

Research & Development (R&D)	Permitting, Siting, & Analysis (PSA)	Infrastructure Security & Emergency Response (ISER)

Technology Development Priorities

- **Visualization and Controls**
  - **Real-time monitoring**
  - **Secure control systems**
- **Distributed Systems**
  - **Phase out activities on single technology development**
  - **Systems integration and Interoperability**
- **High Temperature Superconductivity**
  - **Wires**
  - **Cables**
  - **Devices**
- **Power Electronics (Switches) and Advanced Materials**







R&D – An Essential Element in OE's Strategy

Accomplishes Grid Modernization, Security and Reliability

- Advanced tools
- Advanced technologies
- Recovery/Prevention - supply disruptions

Builds partnerships with the key stakeholders who plan and operate critical national infrastructure

- Energy supply/delivery industries
- State agencies
- Equipment and knowledge suppliers

Spurs innovation, entrepreneurship, business development, and jobs creation

- Global economic competitiveness
- U.S. technology leadership
- Training the "next generation" of scientists, engineers, and entrepreneurs
- Goes beyond traditional practice/paradigm shift

High Temperature Superconductivity (HTS)

- Develop HTS wire with 100 times the power capacity of conventional copper wires at a comparable cost ($/kiloamp-meter).

- Develop HTS electric power equipment with one-half the energy losses and one-half the size of conventional units.

Benefits

- ✓ **Congestion relief – transmit more power through a smaller footprint**
- ✓ **Efficiency – T&D system, large motors**
- ✓ **New capabilities – Fault current limiters, low impedance power lines control regional electricity flow**
- ✓ **Military – smaller motors enable improved naval ship design, smaller generators enable airborne non-lethal air force electromagnetic weapons**

High Temperature Superconductivity (HTS)

A technology capable of revolutionizing electric power systems

Benefits

- ✓ **Congestion relief – Transmit more power through a smaller footprint, higher power densities**
- ✓ **Efficiency – Energy saving through near zero line losses - T&D system, large motors**
- ✓ **New capabilities – Fault current limiters, low impedance power lines control regional electricity flow**




Highlight: Three Cable Projects

- **Albany, NY: Distribution Cable (National Grid – host utility) Operating since 8/2006**
- **Columbus, Ohio: Distribution Cable (American Electric Power – host utility) Operating since 8/2006**
- **Long Island, NY: Transmission Cable (Long Island Power Authority – host utility) Will begin operation in 2007**

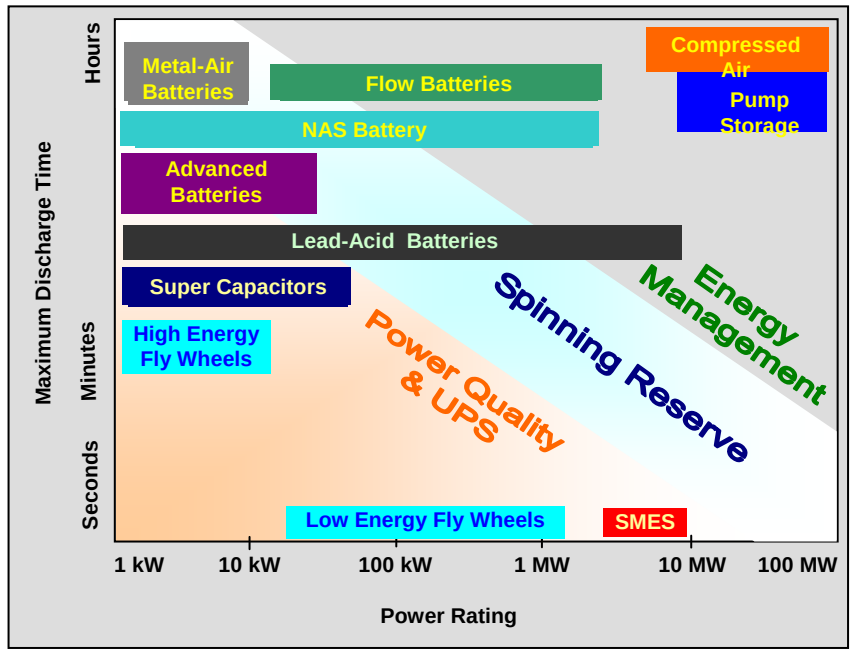
Total Budget: $82M (50/50 cost-shared)

Energy Storage – A Key System Component

Lower-cost storage could revolutionize grid planning and operations

Benefits

- ✓ **Increases grid reliability**
- ✓ **Reduces system transmission congestion**
- ✓ **Helps manage peak loads**
- ✓ **Makes renewable electricity sources more dispatchable**



Energy Storage

Long-term Goal

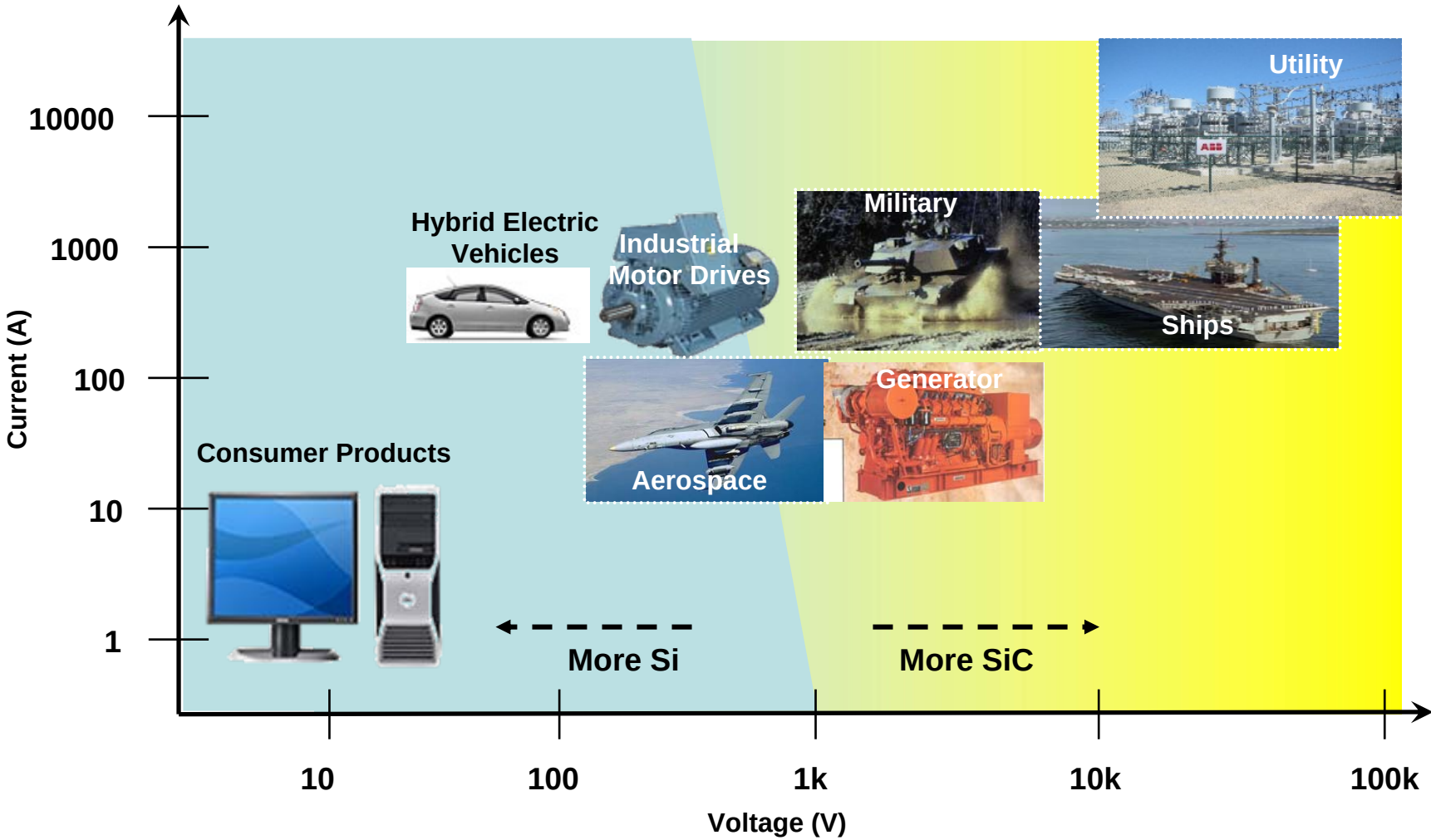
By 2030 there will be prototype super-capacitors and/or battery systems with operating voltages that are two-to-three times greater than today's systems or have a five-fold increase in stored energy.

	2006	2007	2008	2009	2010	2011	2012
Systems	3 systems installed with CEC	2 systems installed with CEC and NYSERDA	--	--	--	--	--
Energy Density (Capacitors and Batteries)	--	--	3 ionic liquids for boosting power by 50%	10% increase in energy density	10% increase in energy density	50% increase in energy density	Factor of 2 increase

Why Power Electronics

Benefits

- ✓ More precise and rapid switching of long-distance power transmission
- ✓ Faster response and better voltage support for local distribution
- ✓ Seamless integration of wind, solar, and other distributed energy systems



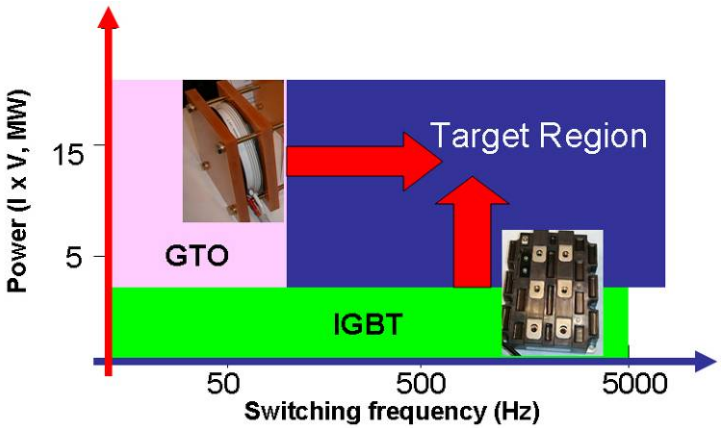
Power Electronics and Advanced Materials

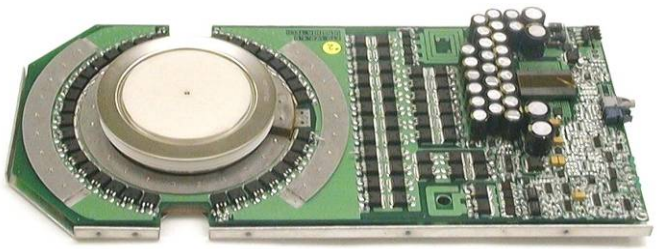
Long-term Goal: **By 2025, demonstrate a prototype solid state breaker (switch) with less than 1 millisecond response. When used in a breaker, these switches will not increase the cost of the system by more than 10%.**

Performance Characteristics	2005 – Baseline	2008	2010	2012	2018	2025
Speed	Current mechanical breakers operate at 4-6 cycles (66 – 100 milli-seconds) Fuses operate in ¼ cycle (4 milli-seconds)		5 milli-seconds	4 milli-seconds	2 milli-seconds	1 milli-seconds
Voltage/Current	Silicon – based switches (fully controllable) 5000 volts and 10 amps	1200 volts/10 amps		10,000 volts/10 amps	20,000 volts/100 amps or 50,000 volts/>10 amps	20,000 volts/500 amps or 50,000 volts/>100 amps
Temperature Limits	Current silicon – based devices are limited to 150°C			250°C		400°C

Development of Emitter Turn-off (ETO) Switch

CURRENT HIGH-POWER SWITCH TECHNOLOGY





R&D 100 Award Winner

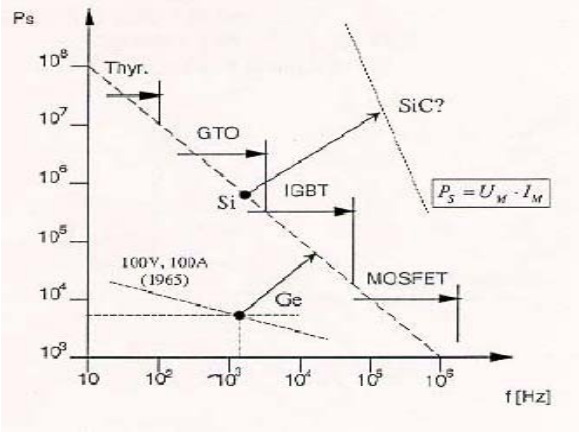
The ETO Switch

- **Developed at Virginia Tech – NC State**
- **15-20 times faster than GTO**
- **3 times the power and potentially less expensive than IGBT**

Plans

- **Development of Gen-4 Device with integrated optical controls**
- **Development of Transmission Stabilization Device with TVA**
- **Field Test of ETO based Statcom for Wind smoothing with BPA**

Silicon Carbide, Wide Band Gap Devices



Higher Voltage, Current
- more power
- lower losses
- smaller device

Higher Temperature and Thermal Conductivity
- less cooling

Higher Frequency
- faster device (2x10^5 Hz)

SBIR Projects

- High power density (100 kW) silicon carbide (SiC) three phase inverters, Arkansas Power Electronics (FY06, Phase II)
- Advanced power converter system using high temperature, high power density SiC devices, Aegis technology (FY06, Phase II)
- Wide band gap, high voltage, high frequency switches (FY07)

Other Technologies

- Gallium-Nitride
- Diamond (3x10^6 Hz)
- Carbon Nano-Tubes (3x10^9 Hz)

Distributed Systems Integration

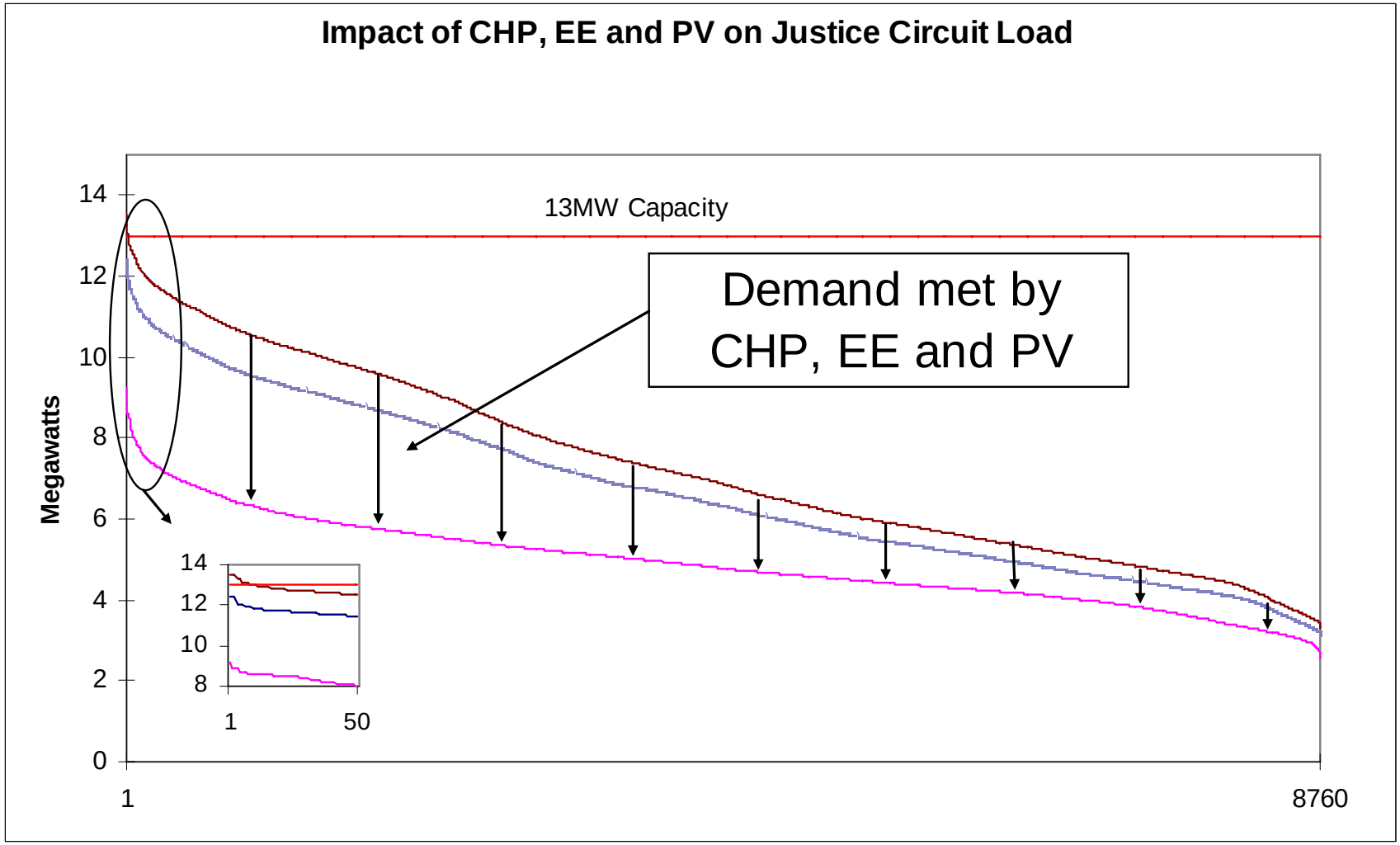
- **Involves development of advanced operational controls for greater interoperability and the seamless integration of distributed systems (generation and storage) with electric grid planning and operations**
- **Includes research, development, field testing, and demonstration of distributed systems for demand response and ancillary services**
- **Provides energy solutions for utilities, customers, and local energy systems such as district energy, power parks, and microgrids**

Benefits

- ✓ **Increases grid reliability**
- ✓ **Addresses vulnerability of critical infrastructure**
- ✓ **Helps manage peak loads and defers T&D investment**
- ✓ **Lowers emissions and utilizes fuel resources more efficiently**
- ✓ **Helps customers manage energy costs**

Why Distributed Systems Integration

Benefits from integrating EE, distributed resources, and demand response

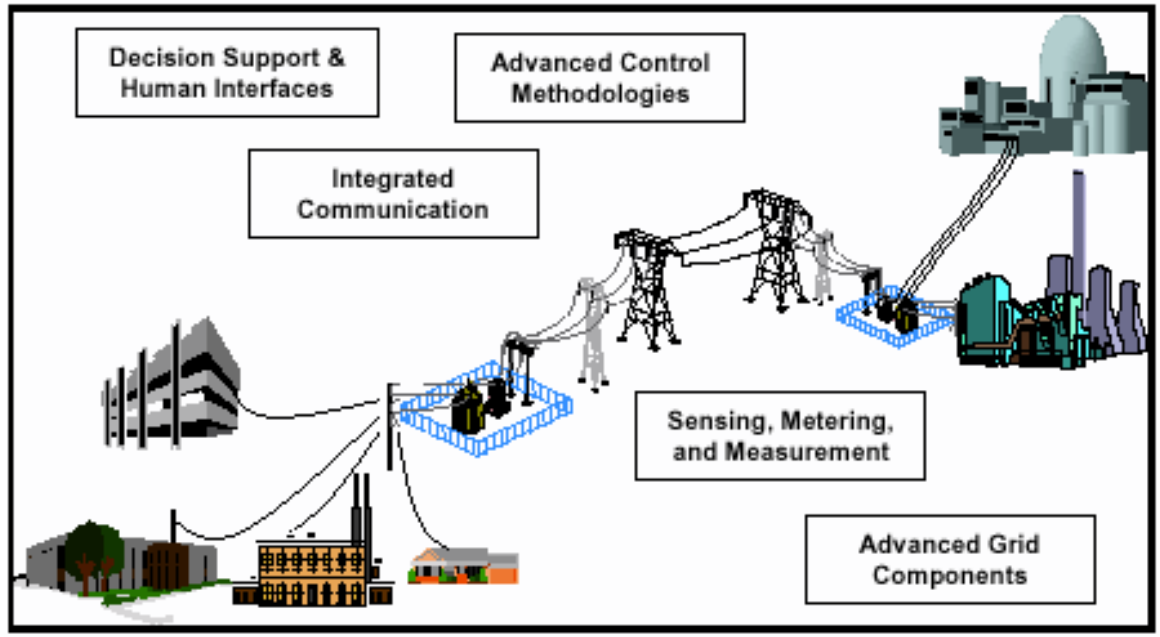


Source: Gas Technology Institute

Modern Grid Initiative
Developmental Field Test (DFT)

Performers/partners

- ***Technology Partners:*** **Softswitch (PQ monitoring); other vendor products being determined**
- ***Utility Partners*****: Allegheny Energy and AEP**



Issues/concerns

- **Several DFT phases are needed to complete integration testing**
- **An integrated team work is critical to success**

Objective

Test the integration of multiple technologies working together in a complex mesh of operations, analysis, alerting, and autonomous decision-making

Distributed Systems Integration

Long Term Goal

To demonstrate a 20% peak-load reduction by 2015, while providing value services and reliability levels required by customers.

	2008 – Baseline	2009	2010	2011	2012	2013	2014	2015
Percent reduction in peak load	0%	5%	10%	10%	15%	15%	15%	20%
Number of feeders analyzed/demonstrated	0	1	2	2	1	2	2	1

V&C - Challenges and Needs for Evolving Industry Structure

CURRENT AND PROPOSED LEVELS:

MONITORING AND CONTROL:

Wide-Area Level 3

DOE Situation Awareness

Situation Awareness for Emergency Response

Wide Area Level 2

FERC Reliability Standards Performance

Standards Performance, Monitoring, Notification and Reporting

Wide-Area Level 1

NERC Emerging Wide-Area Reliability Performance Monitoring and Compliance

Real Time Wide-Area Monitoring and Compliance for Interconnections Load-Generation, Inter-Area Schedules, And Transmission Adequacy

Level 3

ENERGY MANAGEMENT SYSTEMS (EMS) RTO, ISO, CONTROL AREA

System State Estimation, Security Analysis, and Security Constraint Dispatch

Level 2

SCADA - REGIONAL CONTROL CENTER

Regional Load-Generation and Grid Switching Control

LOCAL CONTROL SUBSTATIONS

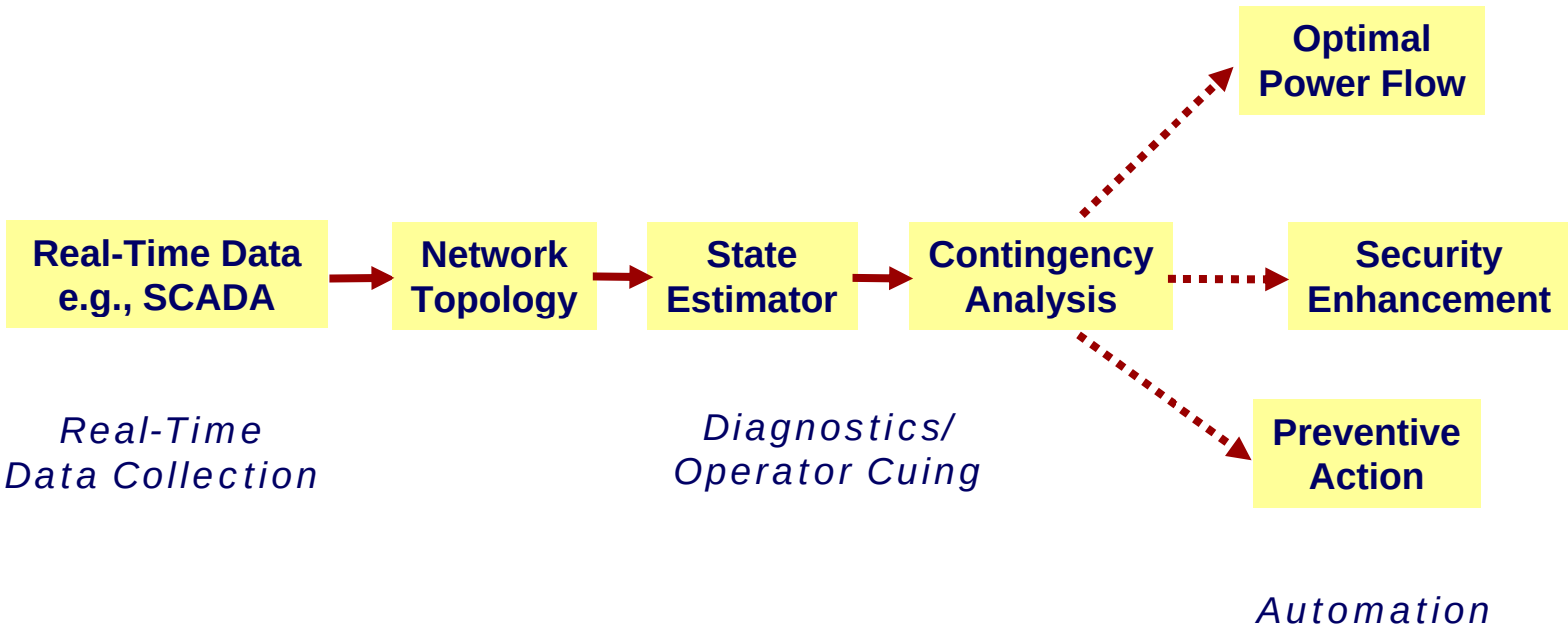
LOCAL CONTROL GENERATION PLANTS

Local Generation and Substation Control

Level 1

V&C Overview

Goal: By 2014, develop tools and algorithms to enable an automatic, smart, real-time switchable network for transmission system operations that enables secure and reliable grid operations, controls major regions of the grid, and is hardened against cyber attacks.



Congestion Study and National Corridor Next Steps - 1221

- **DOE has opened a 60 day comment period ending October 10, 2006 requesting comment on:**
  - **The congestion study and subsequent analyses**
  - **If and where National Corridors should be designated and how they should be bounded**
- **DOE will consider designating National Corridors in all three congestion areas**
- **DOE plans to issue annual Congestion Area Progress Reports detailing progress made in the congestion areas**
- **Next congestion study is due August 8, 2009**

EPACT Sec. 368: Identification of Energy Corridors on Federal Lands

DOE, Agriculture, Interior, Commerce and DOD shall:

- **Designate corridors for oil, gas and hydrogen pipelines and electricity transmission facilities *on federal land* in the eleven contiguous Western states by August 2007; same by Aug 2009 for federal land in East, AK, and HI.**
- **The draft EIS required for designation of the western corridors will be published about 12/31/2006.**
- **Energy corridors in the West will be integrated into agency land use and resource management plans in August 2007.**
- **Extensive discussions with states, tribes, agencies, and industry continue as part of EIS preparation. Preliminary corridor map issued June 2006. Eastern study not yet begun.**

Additional Information

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